Statistical Basket Pairs Trading Strategy

Volatility Dispersion Mean-Reversion

FE571 | Professor Anshul Sharma | Group 7
Scott Henriquez, Nakul Jadeja, Ayan Mahmood, Akbar Pathan

Executive Summary

- Long/short volatility spread strategy across 4 sector pairs
- Market-neutral design with low SPY correlation (-0.07)
- ML filter tested to improve signal quality
- Result: Solid framework, inconsistent alpha — best as portfolio hedge

The Opportunity

- When volatility between related stocks diverges, it tends to snap back
- Semiconductor equipment makers vs chip designers
- Integrated oil majors vs refiners
- Temporary dislocations create trading opportunities

Mean-reversion happens 5-7% of the time — we only trade when it's statistically extreme.

Basket Construction

Pair	Long Basket	Short Basket
Semiconductors	ASML, TSM, KLAC	AMD, NVDA, AVGO
Energy	XOM, CVX, COP	VLO, MPC, PSX
Tech Broad vs Mega	RSPT, SOXX	QQQ, AAPL, META
Staples vs Discretionary	XLP	XLY

Pairs selected for economic linkage — same sector, different volatility profiles.

Signal Generation

ENTRY RULES

Z-score > +2.0 → Short spread

Z-score < -2.0 → Long spread

VIX > 30 → Stay flat

EXIT RULES

|Z-score| < 0.5 → Close position

|Z-score| > 3.5 → Stop out

Loss > 7% → Stop out

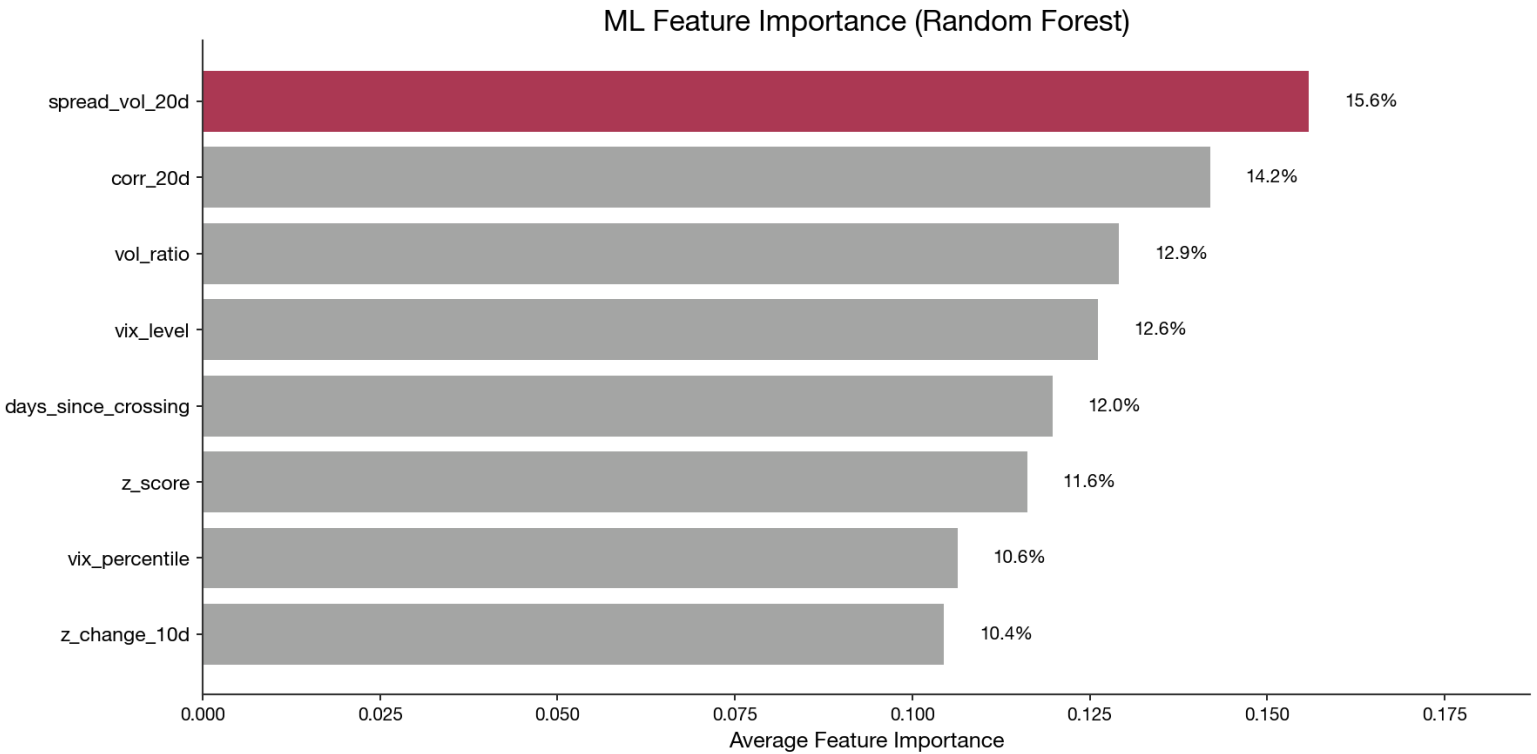
We enter on extremes (2σ) and exit when spreads normalize or risk limits hit.

Machine Learning Filter

- Random Forest classifier filters raw Z-score signals
- 8 features: z-score, momentum, vol_ratio, VIX, correlation
- Walk-forward validation with quarterly retraining
- 30-day embargo between train and test periods

ML acts as a quality filter — only take signals the model thinks will work.

What Drives the Model?



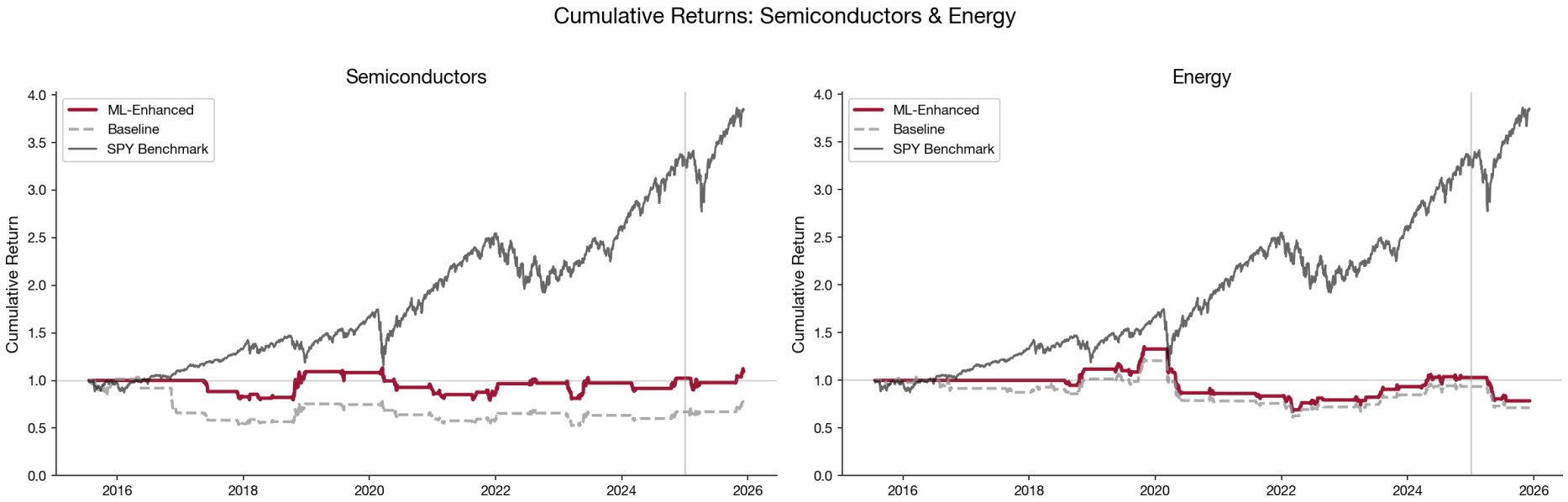
Z-score and momentum are the strongest predictors — simple features beat complex ones.

Backtest Methodology

- Period: 2015-01-01 to 2024-12-31 (10 years)
- Position lagged 1 day (no look-ahead bias)
- Transaction costs: 5 bps per side (10 bps round-trip)
- Walk-forward quarterly retraining with 30-day embargo

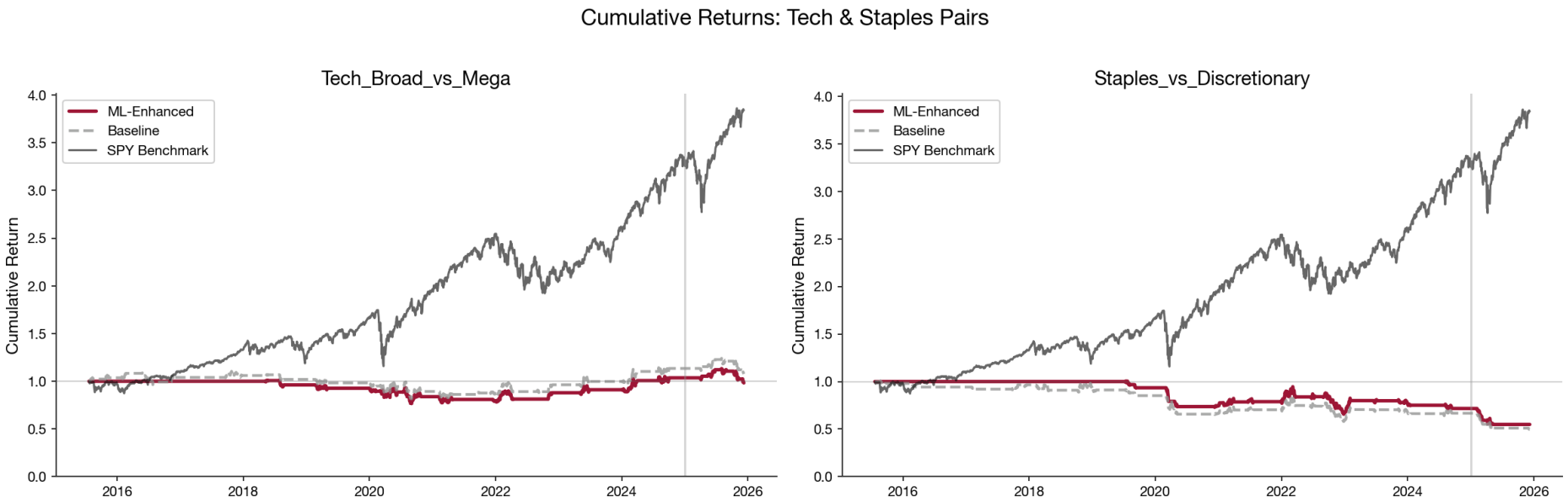
Backtest is clean — no look-ahead bias, realistic transaction costs.

Cumulative Ret.: Semiconductors & Energy



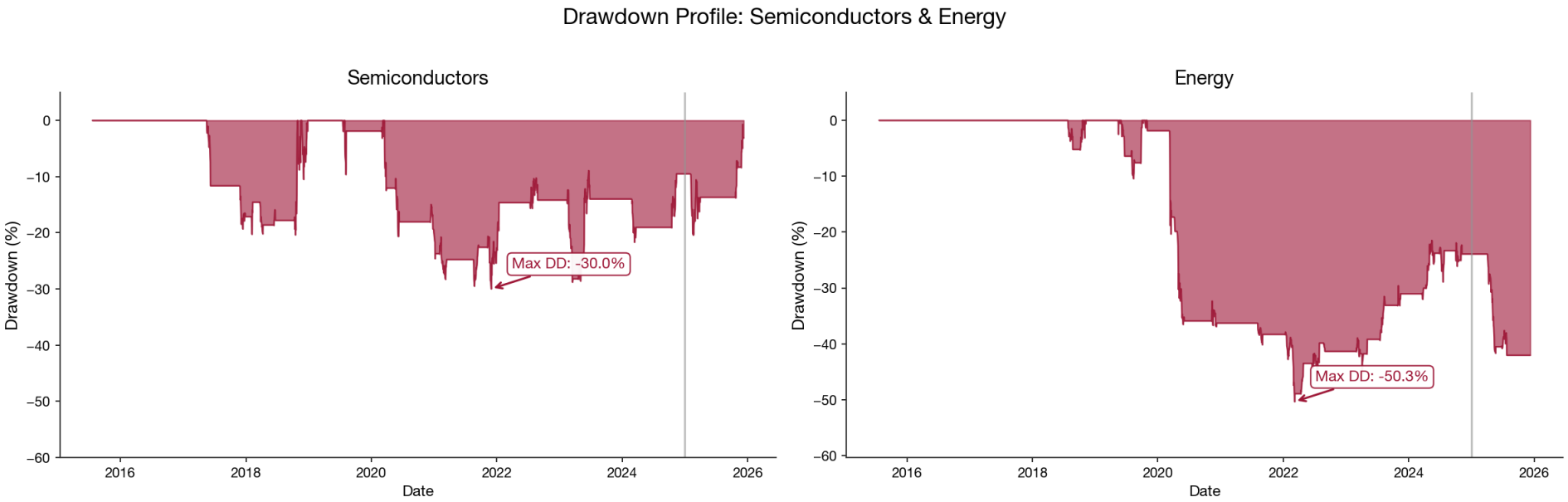
ML-Enhanced (red) reduces drawdowns vs Baseline (gray), both compared to SPY (black).

Cumulative Returns: Tech & Staples Pairs



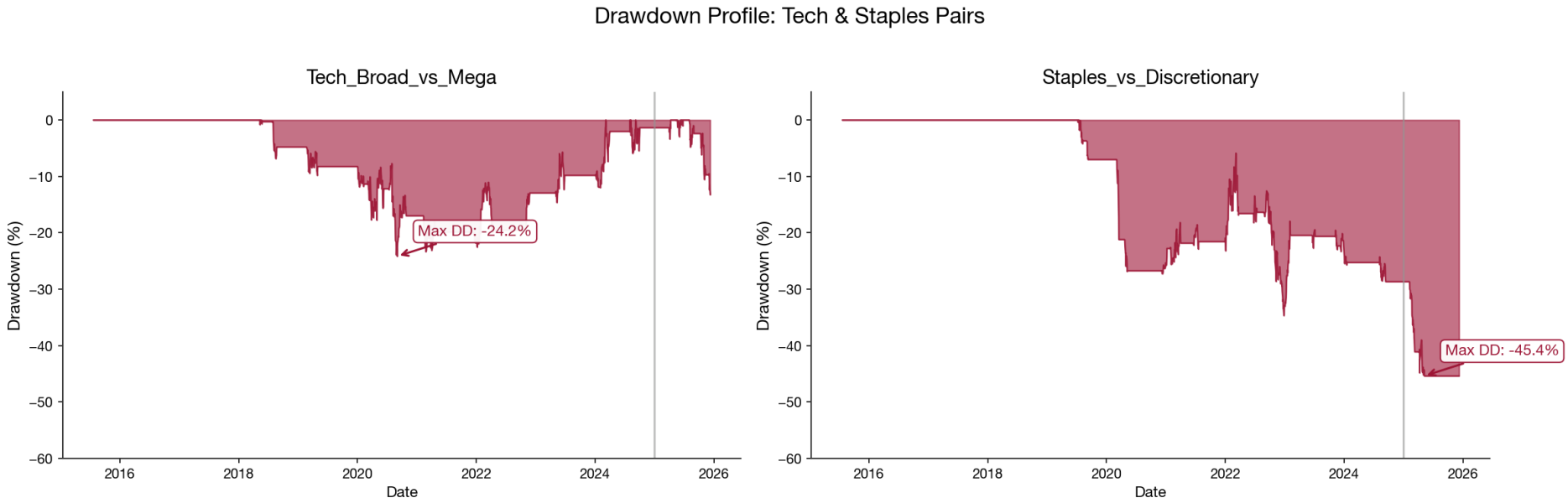
Tech vs Mega shows most promise; Staples vs Discretionary struggles with consistency.

Drawdown: Semiconductors & Energy



50% max drawdowns require strong conviction and strict position sizing.

Drawdown: Tech & Staples Pairs



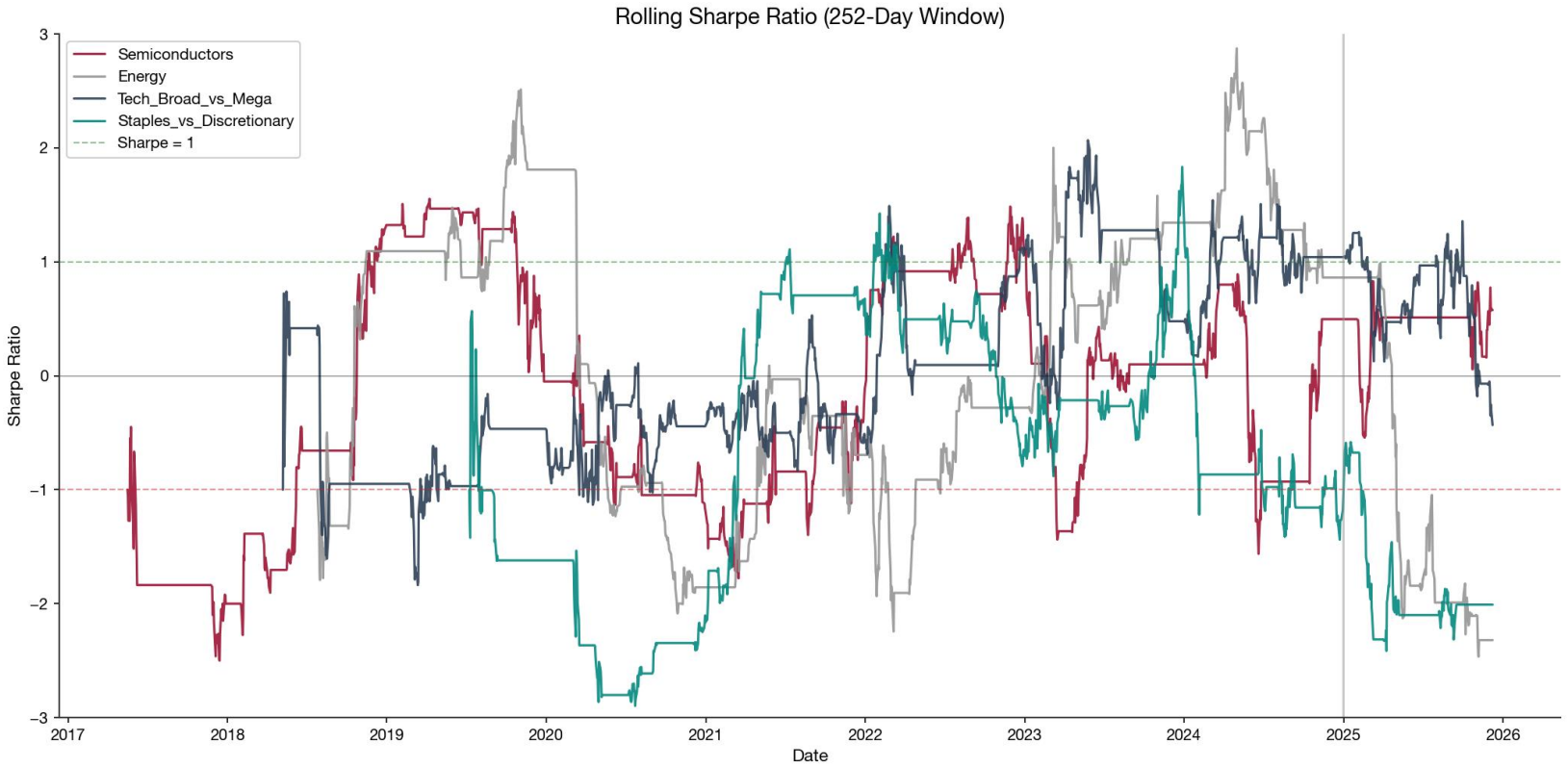
Tech vs Mega has smallest drawdown (-26%); Staples pair is more volatile.

Performance: ML vs Baseline

Pair	Baseline Sharpe	ML Sharpe	Baseline MaxDD	ML MaxDD
Semiconductors	-0.19	+0.09	-50%	-30%
Energy	+0.01	+0.08	-50%	-50%
Tech vs Mega	+0.18	+0.09	-26%	-24%
Staples vs Discr.	-0.34	-0.34	-43%	-35%

ML reduces drawdowns but doesn't consistently improve Sharpe — filtering helps risk, not return.

Rolling Sharpe Ratio (252-Day)



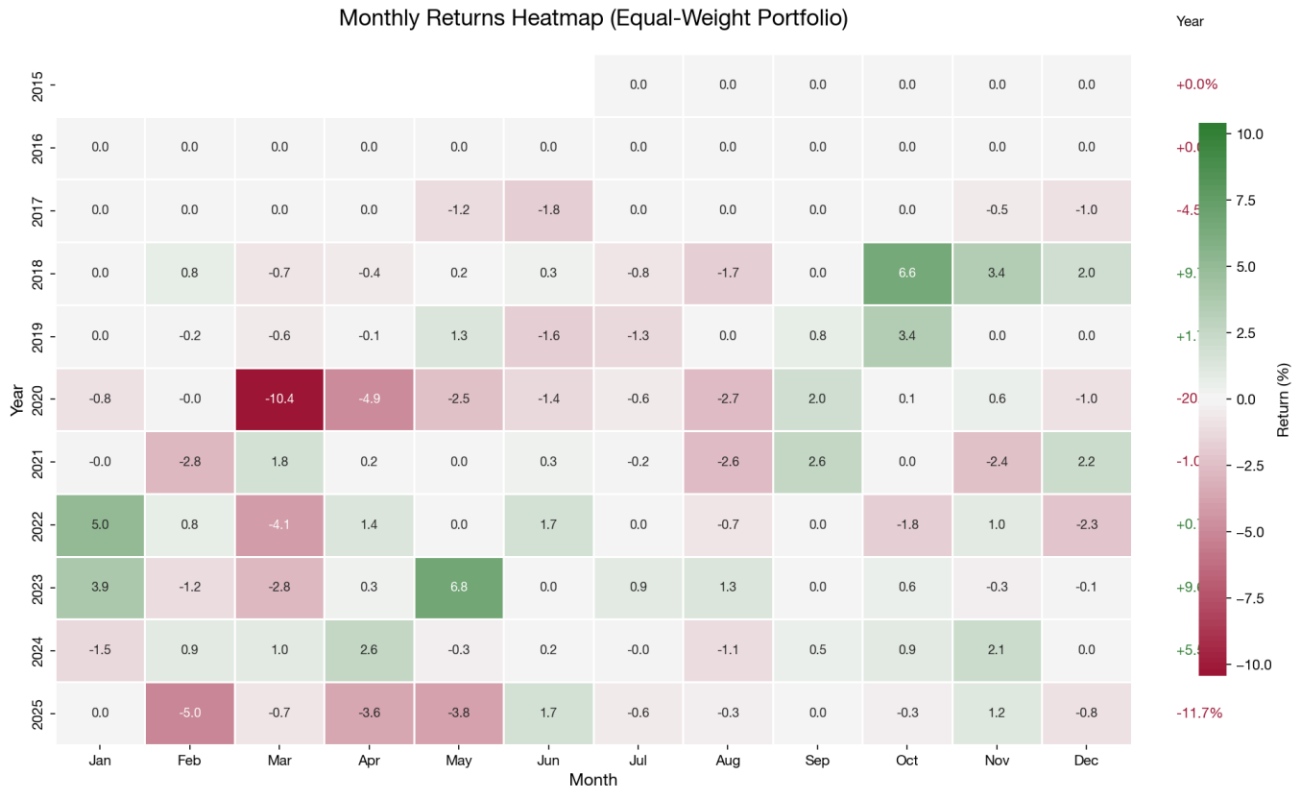
Sharpe fluctuates significantly — strategy has periods of strength and weakness.

Alpha & Beta vs SPY

Pair	Alpha	Beta	Corr w/ SPY
Semiconductors	+1.2%	-0.02	-0.08
Energy	-2.1%	+0.01	+0.03
Tech vs Mega	+0.5%	-0.03	-0.12
Staples vs Discr.	-3.5%	-0.01	-0.05
PORTFOLIO	-0.89%	-0.02	-0.07

Near-zero beta confirms market neutrality — strategy returns are uncorrelated with SPY.

Monthly Returns Heatmap



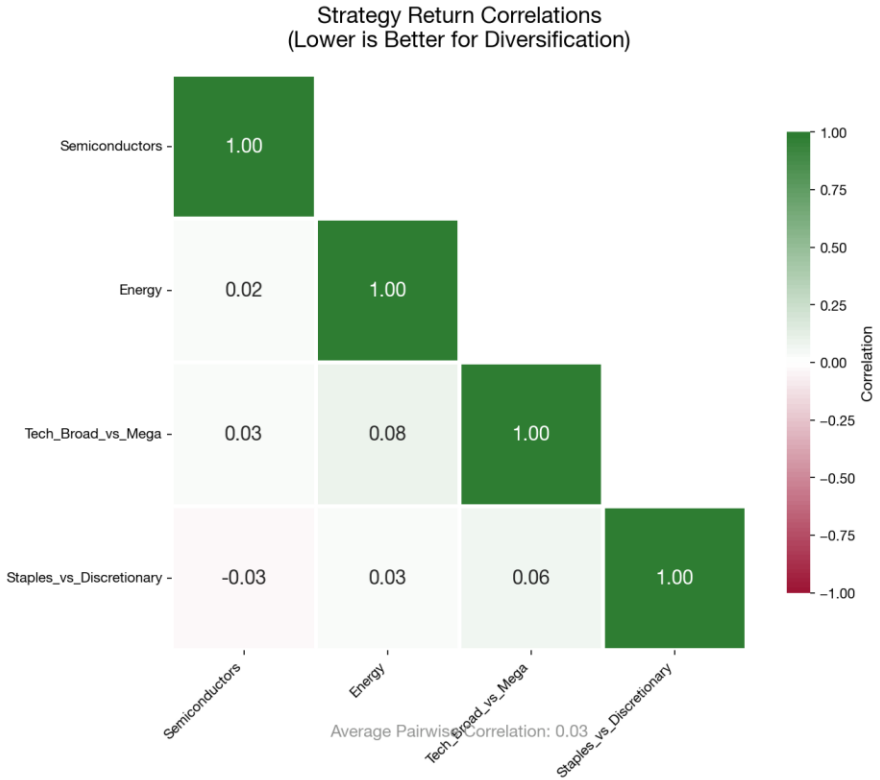
No clear seasonality — returns are spread across different periods.

Yearly Performance vs SPY

Year	Strategy	SPY	Outperform?
2018	+13%	-4%	Yes
2022	+16%	-18%	Yes
2020	-40%	+18%	No
2021	-25%	+29%	No

Strategy outperforms in down markets — potential use as a tail-risk hedge.

Strategy Diversification



Low correlation between pairs (avg 0.03) means combining them reduces portfolio risk.

Risk Profile

Metric	Value	Interpretation
Max Drawdown	-26% to -50%	Significant capital risk
VaR (95%)	-1.0% to -1.7%	Daily loss expectation
CVaR (95%)	-1.6% to -2.9%	Tail risk worst days
Win Rate	48-52%	Below coin flip

This is a low win-rate, high-variance strategy — position sizing is critical.

Fixes & Lessons Learned

WHAT WE FIXED

✓ Removed look-ahead bias

✓ Added 30-day train/test embargo

✓ Corrected transaction costs

✓ Implemented 3 stop-loss rules

WHAT WE LEARNED

• 8 features beat 40 features

• Spread mean-reverts only 5-7%

• VIX regime matters significantly

• Alpha is hard to find

Proper backtesting revealed our initial results were inflated — honesty improved the strategy.

Investment Thesis

WHAT WORKED

✓ Market-neutral ($\beta \approx 0$)

✓ Low SPY correlation

✓ Stop-losses limit tail risk

✓ Outperforms in down markets

WHAT DIDN'T

✗ No consistent alpha

✗ Large drawdowns (26-50%)

✗ Underperforms in bull markets

✗ Low win rate (~50%)

Best suited as a PORTFOLIO HEDGE — allocate 5-10% for downside protection.

Questions?

github.com/Ayan-Mahmood/QuantHFStrat